FINDINGS OF THE IPCC FOURTH ASSESSMENT REPORT – IMPLICATIONS FOR ADAPTATION IN SMALL VULNEARABLE COMMUNITIES

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Direct Observations of Recent Climate Change

Since the IPCC-TAR, progress in understanding the spatial and temporal changes in climate has been gained through:

- improvements and extensions of numerous datasets and data analyses;
- broader geographical coverage;
- better understanding of uncertainties; and
- Measurement & observation of a wider range of variables.

Direct Observations of Recent Climate Change

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.

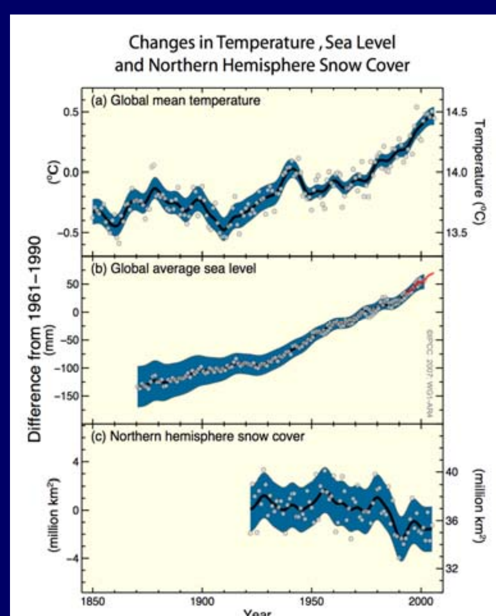
Direct Observations of Recent Climate Change

• Mean global temperature - updated 100 year linear trend of <u>**0.74 ^{0}C**</u> [0.56-0.92^0 C] for the period 1906-2005.

•Larger than trend of 0.6 ^{0}C [0.4-0.8^0 C] for the period 1901-2000 reported in the TAR.

Global average sea level change

Northern hemisphere Snow cover change



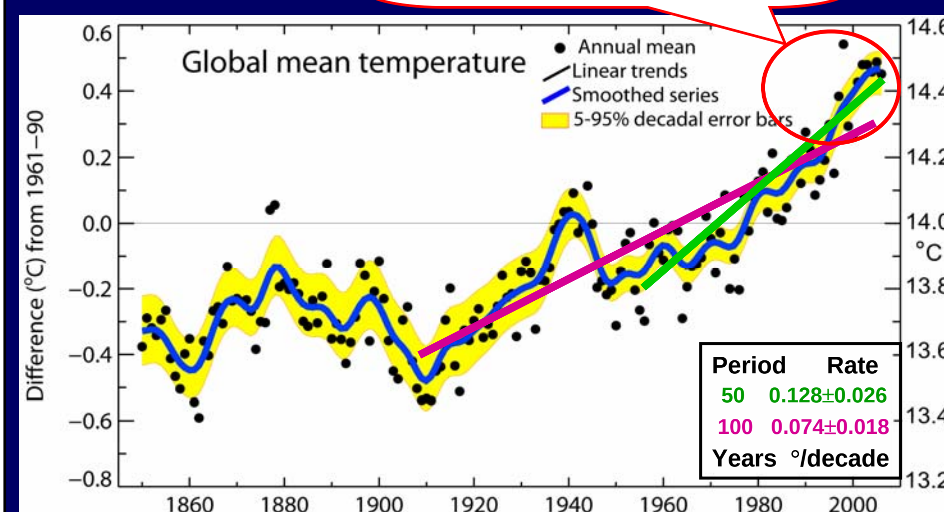
Direct Observations of Recent Climate Change

At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include:

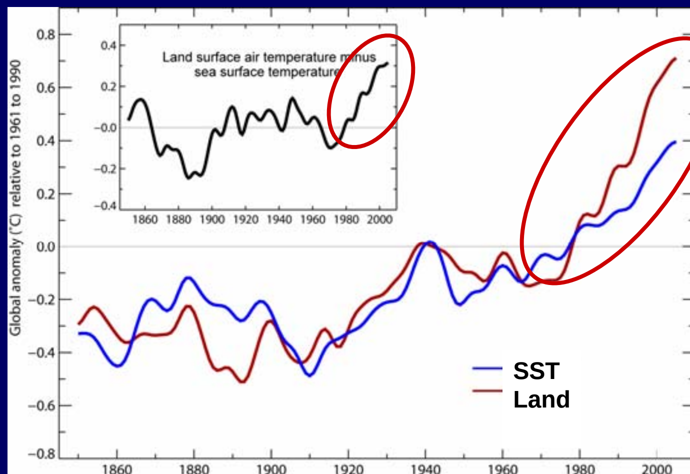
- Widespread changes in precipitation amounts, ocean salinity, wind patterns
- Aspects of extreme weather including droughts, heavy precipitation events, heat waves and the *intensity* of tropical cyclones

Global mean temperatures are rising faster with time

Warmest 12 years:
1998,2005,2003,2002,2004,2006,
2001,1997,1995,1999,1990,2000



Land surface temperatures are rising faster than SSTs



Changes in Precipitation & Increased Drought

- Significantly increased precipitation in eastern parts of North and South America, northern Europe and northern and central Asia.
- The frequency of heavy precipitation events has increased over most land areas - consistent with warming and increases of atmospheric water vapour content
- Drying in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.
- More intense and longer droughts observed since the 1970s, *particularly in the tropics and subtropics.*

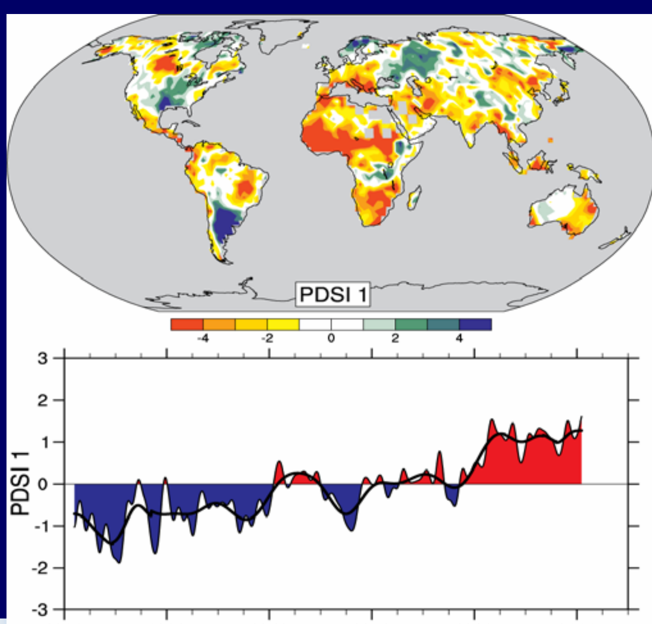
Other Changes in Extreme Events

- Widespread changes in extreme temperatures observed, including:

►Cold days, cold nights and frost less frequent

►Hot days, hot nights, and heat waves more frequent

Drought is increasing most places



Monthly Palmer Drought Severity Index (PDSI), 1900 to 2002 (top)

The time series (below) accounts for most of the trend in PDSI.

Why Should We Be Concerned About Anthropogenic CO_2 ?

- Natural CO_2 sources (respiration of animals and plants; evaporation from the oceans) combined →150 billion tonnes of carbon dioxide each year.
- Anthropogenic CO_2 emissions from combustion of fossil fuels, waste incineration, deforestation → 7 billion tonnes/yr.

HOWEVER

- Natural removal processes (e.g., photosynthesis by land and ocean-dwelling plant species) cannot keep pace with the extra input of man-made CO_2 → consequently the gas is building up in the atmosphere.

  ► CO_2 radiative forcing increased by 20% from 1995 to 2005, the largest in any decade in at least the last 200 years

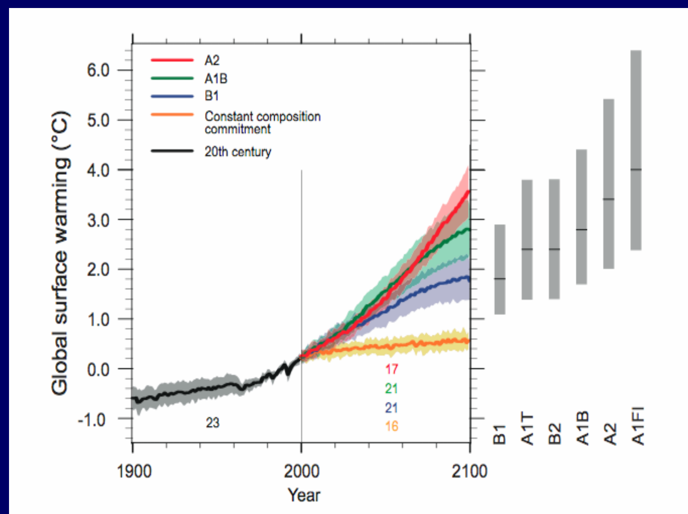
Projections for Future Changes in Climate

- For the next two decades a warming of about 0.2°C per decade is projected for a range of GHG emission scenarios.
- Even if the concentration of all greenhouse gases and aerosols are kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected.
- Previous IPCC projections of a temperature rise 0.15 to 0.3^{o} C/per decade now supported by an observed global value of 0.2^{o} C/decade.

Projections of Future Changes in Climate

Best estimate for low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and for high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C).

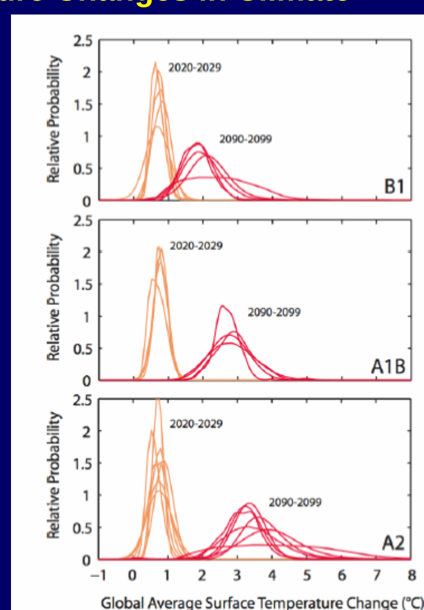
Broadly consistent with span quoted for SRES in TAR.



Projections of Future Changes in Climate

Near term projections insensitive to choice of scenario

Longer term projections depend largely on emission pathways (and climate model sensitivities).

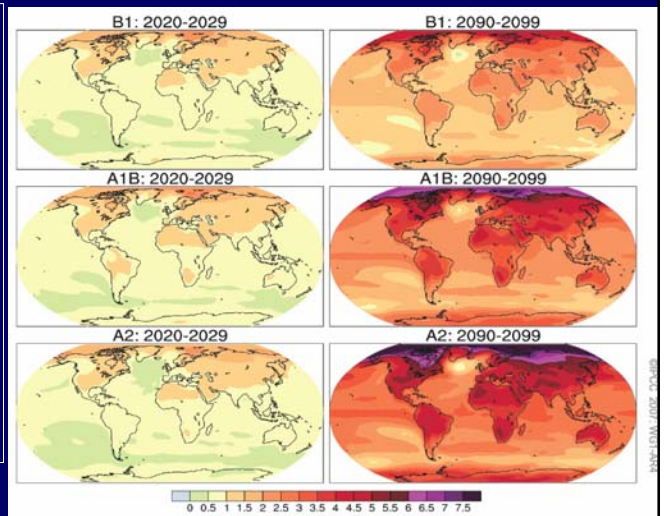


Projections of Future Changes in Climate

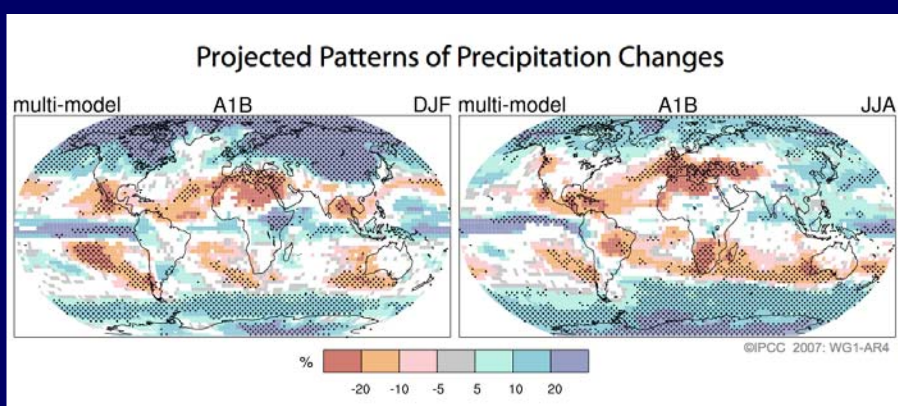
Projected warming in 21st century expected to be:

► greatest over land and at most high northern latitudes

► least over the Southern Ocean and parts of the North Atlantic Ocean



Projections of Future Changes in Climate



Precipitation increases *very likely* in high latitudes

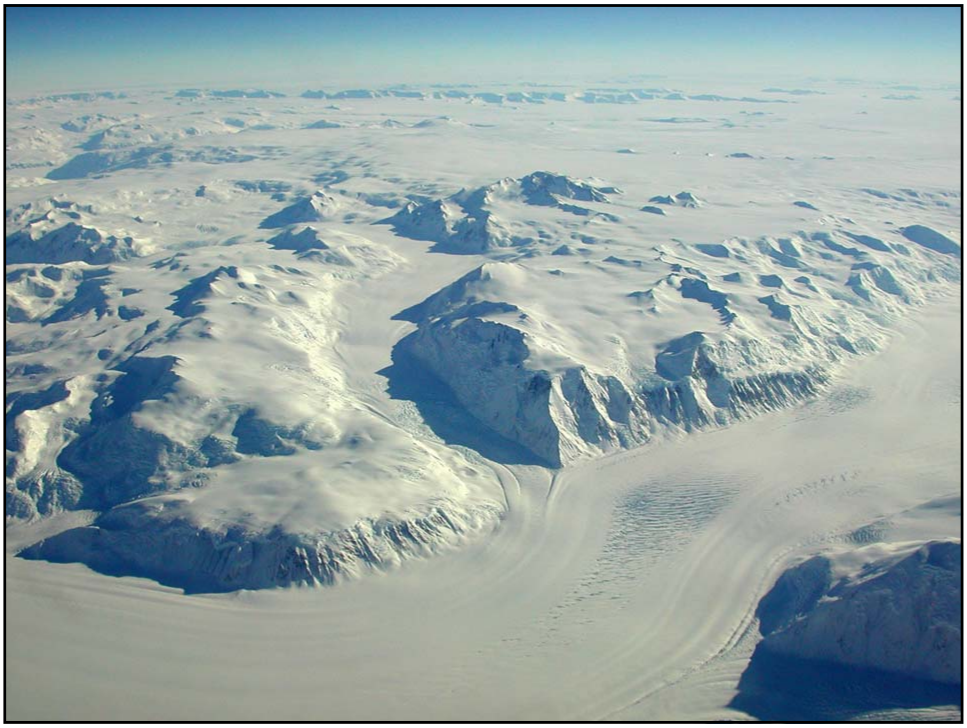
Decreases *likely* in most subtropical land regions

Projections for Future Changes in Climate

- Snow cover is projected to contract
- *Very likely* that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent
- *Likely* that future tropical cyclones more intense, less confidence in decrease of total number
- Extra-tropical storm tracks projected to move poleward with consequent changes in wind, precipitation, and temperature patterns

Projections for Future Changes in Climate

- Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized.
- Temperatures in excess of 1.9 to 4.6°C warmer than pre-industrial sustained for millennia…eventual melt of the Greenland ice sheet. Would raise sea level by 7 m. Comparable to 125,000 years ago.



What Can Our Friends in the Far North Expect?

- Average temperatures in the Arctic region are rising twice as fast as they are elsewhere in the world. Arctic ice is getting thinner, melting and rupturing.
  - ► For example, the largest single block of ice in the Arctic, the Ward Hunt Ice Shelf, had been around for 3,000 years before it started cracking in 2000. Within two years it had split all the way through and is now breaking into pieces.
- The polar ice cap as a whole is shrinking. Images from NASA satellites show that the area of permanent ice cover is contracting at a rate of *9 percent/ decade*. If this trend continues, summers in the Arctic could become ice-free by the end of the century.

► During the summer of 2004, hunters found half a dozen polar bears that had drowned about 200 miles north of Barrow, on Alaska's northern coast. They had tried to swim for shore after the ice had receded 400 miles. A polar bear can swim 100 miles—but not 400!

Changes in Arctic Sea Ice (NASA)

Observed impacts of climate change on the natural and human environment*

- Observational evidence from all continents and most oceans indicates that natural systems are being affected by regional climate changes, particularly temperature (*high confidence*)
- Hydrologic systems around the world are being affected: "increased runoff and earlier spring peak discharge in many glacier-and snow-fed rivers (*High confidence*)
- Recent warming is strongly affecting terrestrial biological systems: "earlier timing of spring events, leaf-unfolding, bird migration, and egg-laying"and "poleward shifts in ranges in plant and animal species" (*Very high confidence*)
- Of more than 29,000 observational data series from 75 studies, that show significant change, more than 89% are significant with the direction of change consistent with warming.

……And Just in Case Mr. Bush Hasn't Noticed…

- Since 1900, sea levels have risen by:

→ 12.3 inches in New York City;
→ 8.3 inches in Baltimore;
→ 7.3 inches in Key West;
→ 22.6 inches in Galveston; and
→ 6.0 inches in San Francisco.

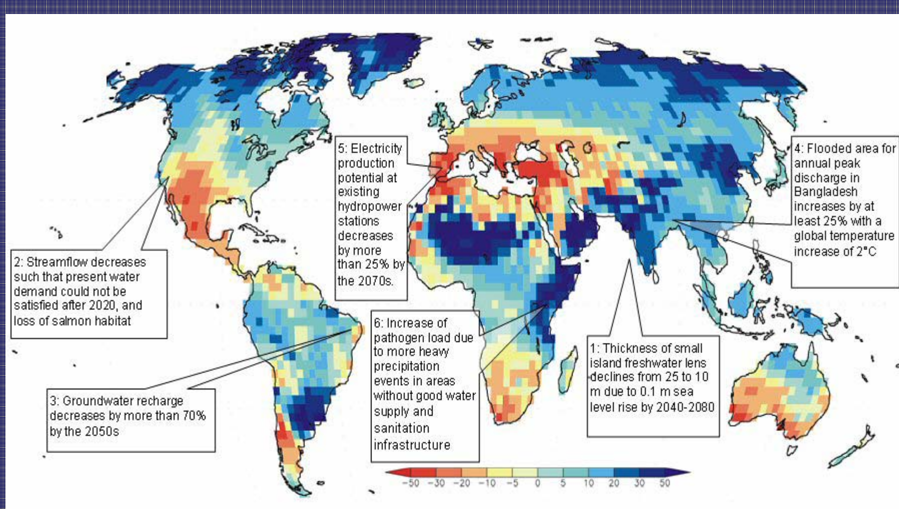
- ….And in the last two decades the rate of rise has been accelerating over time.

The wide range results from the rising or falling of the land itself. San Francisco is rising; the East and Gulf coasts are subsiding.

What Can We Expect In Tropical Small Islands?

- Water Resources
- Water resources in small islands especially vulnerable to changes in rainfall distribution. Low rainfall typically leads to (a) reduction in the amount of water that can be harvested (b) reduction in river flow, and (c) a slower rate of recharge of the freshwater lens, which can result in prolonged drought.
- Recent modeling of the current and future water resource availability on several small islands in the Caribbean, using a *macro-scale hydrological model* (Arnell, 2004) found that many of these islands would be exposed to severe water stress. Since most of the islands are dependent upon surface water catchments for water supply, it is highly likely that demand would not be met during low rainfall periods.
- Recognising the vulnerable nature of water supplies, several countries (e.g. The Bahamas, Antigua and Barbuda, Barbados) have begun to invest in the implementation of adaptation strategies, including desalination and rainwater harvesting, to offset current and projected water shortages.

Water



Impact of Sea-Level Rise

- Sea-level rise will exacerbate inundation, erosion and other coastal hazards, threatening vital infrastructure, settlements and facilities that are predominantly situated along the coast.
- Sea-level rise will also negatively impact coastal ecosystems such as coral reefs and mangrove forests, and commercial and artisinal fisheries based on those systems. These adverse effects are likely to manifest themselves through reduced abundance, loss of diversity and possibly shifts in distribution as a result of migration.
- Since fisheries contribute significantly to GDP in many island states, the socio-economic implications of the impact of climate change on fisheries will be important.

Agriculture and Food Security

- Agriculture impacted by extended periods of drought and reduced soil quality through increasing soil salinization especially near coastal areas. The World Bank (2000, 2002) found that a country such as Fiji could experience damages of 23 million to 52 million USD per year by 2050, (equivalent to 2-3 percent of Fiji's GDP in 2002). Low islands such as Kiribati could face average annual damages of more than 8 million to 16 million USD a year (equivalent to 17-18 percent of Kiribati's GDP in 2002), as a result of climate change.
- The AR4 also notes that reduced crop productivity in traditional markets from which small islands obtain their food, will drive prices up → food importation costs will inevitably rise in response to market forces.
- Extreme events (e.g. hurricanes, floods, droughts) can also cause severe damage to food and commercial crops. The case of Grenada after hurricane Ivan is an excellent example. Nutmeg, Grenada's most important agricultural crop, was devastated in a mere few hours by the hurricane. Since the plant does not reach commercial production status under 7-8 years, Grenada will earn no foreign exchange from this source for almost a decade.

Infrastructure and Housing

- In the Caribbean, more than half of the population lives within 1.5 km of the shoreline. In locations such as the north coast of Jamaica and the west and south coasts of Barbados, continuous corridors of development occupy practically all of the prime coastal lands. Other facilities such as fishing villages, government offices, hospitals and critical utilities are frequently located close to the shore. Changes in sea level, and the characteristics of storm events, are likely to have serious consequences for these settlements and infrastructure.
- Almost without exception, international airports are sited on or within a few km. of the coast. Similarly, the main road arteries often parallel the coast. With projected sea-level rise, much of this infrastructure would be at risk from flooding and physical damage, although the degree of risk will obviously vary from country to country.
- The threat from sea-level rise to infrastructure is amplified with the passage of tropical cyclones (hurricanes). It has been shown for instance that the sea ports at Suva, Fiji, and Apia, Samoa, would experience overtopping, damage to wharves and flooding of the hinterland with a 0.5 m rise in sea level combined with waves from the 1: 50 year cyclone. In the Caribbean, damage to coastal infrastructure from storm surge alone is often significant. In November 1999, surge damage in St. Lucia associated with Hurricane Lenny exceeded US$ 6.0 million, although the storm was many kilometres offshore.

Human Health

- Climate change is also likely to result in an increase in the incidence of vector-borne diseases such as dengue fever and malaria. The various mosquitoes that transmit these diseases, as well as other environmental factors in disease transmission, are clearly influenced by climate. In the Caribbean, a retrospective review of dengue fever cases (1980-2002) was carried out in relation to ENSO events (Rawlins *et al.,* 2005). This showed there were greater occurrences of dengue fever in the warmer drier period of the first and second years of El Niño events. Normally, however, it is in the wet season that Caribbean countries are at greatest risk to dengue fever transmission, suggesting that vector mitigation programs should be targeted at this time of year to reduce mosquito production and dengue fever transmission (Rawlins *et al.,* 2005).
- Shortages of fresh water and poor water quality during periods of drought, as well as contamination of fresh water supplies during floods and storms appear to lead to an increased risk of disease including cholera, diarrhoea, and dengue fever. Ciguatera fish poisoning is also common in marine waters, especially reefal waters. Although multiple factors contribute to outbreaks of ciguatera poisoning, including pollution, and other forms of reef degradation, warmer sea surface temperatures during El Niño events have also been linked to ciguatera outbreaks.

Tourism

- Tourism is a major economic sector in many islands, and the effects of climate change will be both direct and indirect. Sea-level rise and increased ocean temperature are projected to accelerate beach erosion, cause degradation of coral reefs including bleaching, and degrade the overall asset value of the coast. Such impacts will in turn reduce the attractiveness of these destinations for coastal tourism. Warmer climates in the higher latitude, especially in winter, may also reduce the number of people who want to visit small islands in tropical and subtropical regions.
- Climate change will also affect vital environmental components of holiday destinations, which could have repercussions for tourism-dependent economies. The importance of environmental attributes in determining the choice and enjoyment of tourists visiting Bonaire and Barbados, two Caribbean islands with markedly different tourism markets and infrastructure, and possible changes resulting from climate change (coral bleaching and beach erosion respectively) have been investigated by Uyarra *et al.,* (2005). They concluded that such changes would have significant impacts on destination selection by visitors, and that island-specific strategies, such as focussing resources on the protection of key tourist assets, may provide a means of reducing the environmental impacts and economic costs of climate change.

Adaptation

- Adaptation to climate change is already taking place, but on a limited basis.
- Adaptation measures are seldom undertaken in response to climate change alone
- Many adaptations can be implemented at low cost, but comprehensive estimates of adaptation costs and benefits are currently lacking
- Adaptive capacity is uneven across and within societies

Adaptive Responses

- A portfolio of adaptation and mitigation measures can diminish the risks associated with climate change. Responses include:
  - purely technical (e.g. infrastructure defenses against sea level rise, improve water use efficiency, demand management e.g. through metering and pricing)
  - Behavioral (e.g. altered food and recreational choices)
  - Managerial (e.g. altered farm practices)
  - Policy (e.g. planning regulations; building codes)
- Adaptation takes time to implement, so an early start is likely to yield more effective results.